# THE SOUTHERN CORN ROOTWORM AND FARM PRACTICES TO CONTROL IT

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Rev.ed.
follows

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UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

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OF ALL CORN PESTS in the South one of the most serious is the larva, or young, of the 12-spotted cucumber beetle—the so-called southern corn rootworm. True to its name, it feeds on the roots, but in young corn it also drills a small hole in the stem just above the first circle of roots, boring out the crown and killing the bud. Attacked plants either die outright or are so badly stunted as to be unproductive. Lowland corn suffers the most and injury is greatest during cool, damp seasons. The adult, or beetle, is also exceedingly destructive; not, however, to corn, but to cucumber, squash, and a great variety of other truck crops and ornamental plants.

Progressive farming methods, as described in this bulletin, will reduce the ravages of this insect. Burn over waste places to destroy dead grass, weeds, and rubbish in which the beetles winter. If possible, avoid planting corn in fields which contained corn the year before. Enrich the soil by planting legumes so that the corn will have a better chance of recovering from rootworm injury. Protect the bobwhite. This bird destroys many beetles of the rootworm. By careful observations, extending over a period of years, find out the dates between which the rootworm does the most damage; then time your planting so that it will fall either before or after these dates, taking into consideration, of course, other important factors in crop production.

# THE SOUTHERN CORN ROOTWORM[1] AND FARM PRACTICES TO CONTROL IT.

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## ECONOMIC IMPORTANCE AND COMMON NAMES.

CORN GROWERS in the Southern States suffer damage from the southern corn rootworm (fig. 1) practically every year. In fact, as a serious corn pest in the South the rootworm has few competitors. During some seasons it is quite a difficult matter to get a stand of corn in the lowlands on account of these worms. During years of heavy infestation it is necessary to replant corn as many as three times and even then only a poor stand is obtained. The loss that may be attributed to the ravages of the pest is probably even greater and more far-reaching than is commonly supposed. Very often weather conditions are blamed for the yellowish and sickly appearance of corn and the resulting poor yield of the crop, when in reality the true cause is southern corn rootworm injury.

FIG. 1.—Southern corn rootworm: Larva or worm, side view. About four and one-half times natural size.

Although this rootworm sometimes damages the corn crop in the more northerly sections of the Middle West, it is not there considered a serious corn pest. A closely allied insect, the western corn rootworm,[2] takes its place as an enemy of corn in these regions.

[1] *Diabrotica duodecimpunctata* Olivier; order Coleoptera, family Chrysomelidae.

[2] *Diabrotica longicornis* Say.

The southern corn rootworm is more commonly known as the "budworm"; in fact, few farmers know it under the former name. It is sometimes termed "drillworm." These names are more or less descriptive of the injury done to the plant by the worms. The adult, or parent, is known as the 12-spotted cucumber beetle, from the fact that it has 12 black spots on its back and is often a serious enemy to cucumbers and allied plants.

## GEOGRAPHICAL RANGE OF THIS AND RELATED ROOTWORMS.

The southern corn rootworm has a very wide distribution. It is found throughout the greater part of the United States from Maine to Florida, and from the Atlantic coast to the Rocky Mountains. It occurs also in Mexico and Canada. It is not recognized, however, as a serious pest of Indian corn north of Maryland and the southern parts of Ohio, Indiana, and Illinois, south of Georgia, or west of the Mississippi River, with the exception of parts of southeastern Texas and southern Louisiana. (Fig. 2.)

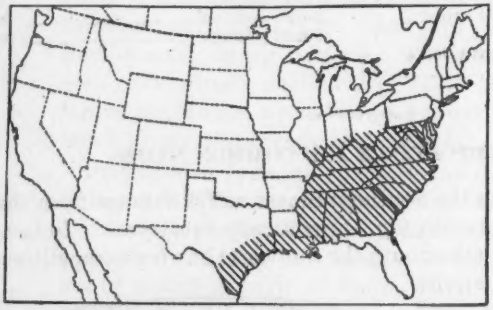

FIG. 2.—Map showing, by shaded area, region where corn is most seriously injured by the southern corn rootworm.

The western corn rootworm[1] occurs from Maine to the Gulf of Mexico and westward to Minnesota, South Dakota, and New Mexico.

In the States bordering the Pacific occurs a closely allied species.[2] This western rootworm is often injurious to various cultivated crops. In southern Texas there is still another species, the belted cucumber beetle,[3] which sometimes does practically as much damage to corn in that region as the southern corn rootworm.

## WHEN SERIOUS INFESTATIONS MAY BE EXPECTED.

Serious infestations of the rootworm may be expected during seasons of abundant rainfall and cool weather, conditions conducive to the development of this insect. Corn in lowlands is more seriously affected than that in uplands, as this insect prefers to breed in moist soil. Thus it is only during years of heavy infestation that corn in uplands is subject to serious damage.

[1] *Diabrotica longicornis* Say. [2] *Diabrotica soror* LeConte. [3] *Diabrotica balteata* LeConte.

## INJURY TO CORN BY THE ROOTWORM.

The worm or larva stage (fig. 1) of this insect is the one most injurious to corn. As the name "corn rootworm" would indicate, it feeds on the roots of corn, but it does not confine its injuries to the roots; indeed, the greatest damage to young corn is that done by the worms in drilling a small hole into the stem directly above the first circle of roots (see title-page illustration) and feeding on the

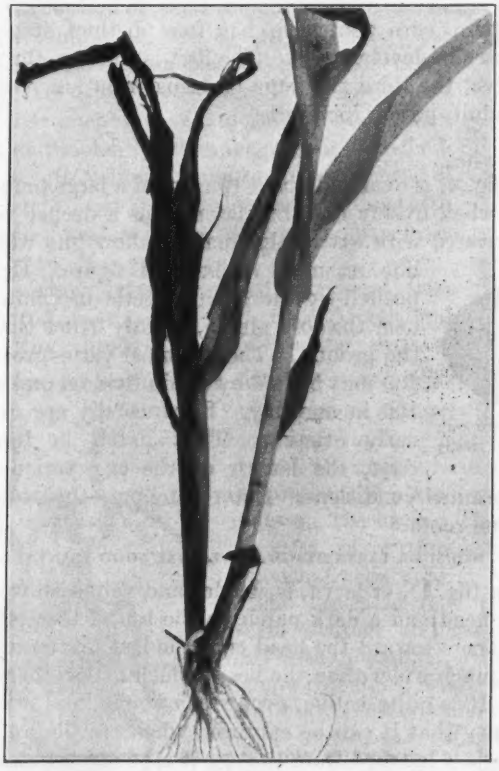

FIG. 3.—Corn plant showing injury by southern corn rootworm to growing point or "bud."

interior, boring out the crown and killing the bud. Plants affected in this way break off at the injured point when an attempt is made to pull them. In older corn the worms injure the roots almost exclusively.

## HOW INJURY TO CORN BY THE ROOTWORM CAN BE RECOGNIZED.

When young corn has been damaged by this insect the fact can be easily detected. The bud leaves of injured plants, having been cut off from the main plant, dry up and die (fig. 3), while the rest

of the plant retains its original color for a time. Subsequently the whole plant dies if injured badly. It is on account of this peculiar manner of injury that the insect is often called the "budworm."

Larger plants when attacked present a sickly yellowish and dwarfed appearance, due to the fact that the worms are feeding on the roots. Very often such plants exhibit a number of suckers, and they produce little or no grain.

## DEVELOPMENT.

The southern corn rootworm has four distinct stages through which it passes in development. The first is the egg, the second the worm or larva, the third the pupa or transformation stage, and the fourth the adult, parent, or beetle.

### EGG STAGE.

The egg (fig. 4) is oval and about the size of a large pinhead. It is dull yellow when freshly laid, but later turns a deeper yellow. Its surface is covered with extremely small, shallow pits which in outline resemble a six-sided figure. Eggs are deposited by the female beetle in contact with or near the corn plants, slightly below the surface of the ground. Their number varies greatly. Over 400 may be laid by one individual and as many as 100 in one day. Eggs usually are deposited in early evening. They hatch in from 6 to 8 days, the length of the egg period depending upon temperature conditions. Upon hatching, the worms attack the stems and roots.

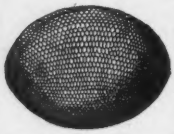

FIG. 4.—Southern corn rootworm: Egg greatly enlarged.

### WORM OR LARVA STAGE AND LARVAL FOOD PLANTS.

The worm (fig. 1), or larva, is slender and yellowish-white, with a dark-brown head and a dark patch on the top of the last body segment. It tapers toward the head end, the last few segments of the body being much wider than the head, which makes them appear as if swollen. It is quite active, even when young, and it is only with great difficulty that it can be captured when crawling about in the soil. When just hatched from the egg it is so small that it is barely perceptible to the unaided eye, but when full grown it can be seen readily, as it is then about one-half inch in length.

Upon examining infested or injured corn the worms may be found in their tunnels or among the roots. Sometimes, however, they are found some little distance away from the injured plants, probably migrating to other corn plants in the same row.

In addition to corn the larvæ of this species are known to feed and live on the roots of Johnson grass, Southern chess,[1] wheat, millet, rye, young oats, and alfalfa.

[1] *Bromus unioloides.*

### PUPA OR TRANSFORMATION STAGE.

After the worm is full grown it enters the ground to a depth varying from a few inches to a half foot or more, the actual depth depending upon the texture of the soil. It then makes a cell somewhat oval in outline and smooths it very evenly on the inside. Presently it begins to shorten, and after an interval of a few days it sheds its skin and passes into the pupa or transformation stage.

A clear conception of what the pupa is like can be formed by examining figure 5. In this stage the insect can not move from place to place and is not destructive. It never leaves its cell. The only part capable of movement is the tip of the abdomen, which is moved about violently when the pupa is disturbed. The pupa is soft, yellowish, and about one-fourth of an inch in length. It is a little longer than the width of its broadest part and has two very conspicuous spines at the tip of the abdomen.

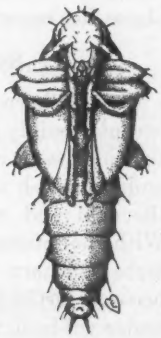

FIG. 5.—Southern corn rootworm: Pupa or resting stage. About eight times natural size

The pupa stage lasts about 10 days and then the 12-spotted beetle, or parent, comes forth and works its way through the soil to the surface of the ground.

### PARENT OR BEETLE STAGE AND FOOD HABITS OF THE BEETLE.

FIG. 6.—Southern corn rootworm: Adult or beetle. About eight times natural size.

The parent or beetle (fig. 6) is about one-fourth inch in length, yellowish-green, with a black head and legs and, as previously stated, with 12 black spots on the back. These spots are irregular in outline and generally somewhat separated.

The beetle is very active during warm weather and can be captured only with difficulty. When feeding, if danger threatens, it falls to the ground and crawls away under rubbish or hides under the foliage of smaller plants. During cool weather it becomes less active, and when the temperature is near freezing it scarcely moves, even when disturbed.

In the beetle stage the insect is quite destructive—not, however, to corn but to certain truck crops such as squashes, cucumbers, etc., and on account of the fact that it is such a serious enemy of these plants the beetle is known as the 12-spotted cucumber beetle. The injury to these plants consists of numerous small holes in the leaves, and if the

plants are small and have only a few leaves a great deal of harm is done unless preventive measures have been taken.

In relation to corn the beetle stage is important as being the egg-laying period of the insect, for the female, after having mated, places her eggs in the soil near the corn plants.

## HOW THE INSECT PASSES THE WINTER.

The southern corn rootworm passes the winter in the beetle stage, except possibly in southern Florida and Texas. In northerly regions the beetles go into hibernation late in the fall; that is, they crawl under rubbish and to other places that afford them protection from the cold and remain in an inactive condition during the winter. With the return of warm weather they again become active. In the more southern States, where temperatures are mild, they do not become torpid in the winter, but during cool days and nights hide under rubbish, among dead grasses, or under low-leaved plants and resume activity when the weather again becomes warm. There are some native plants which remain green throughout the winter in the South and beetles have been found feeding on them, as well as on rye, oats, and other field crops, during warm days in midwinter.

## NUMBER OF GENERATIONS ANNUALLY.

The exact number of generations of this species as yet has not been determined definitely for any one locality. There appear, however, to be at least two generations in the North and three in the South. As a pest of corn in the South the first two generations only need be considered, and as a rule most of the damage is done by the first generation of the year.

## NATURAL ENEMIES.

### NATIVE BIRDS.

A number of our native birds prey upon the adults, or beetles, of the southern corn rootworm. Some of the common ones are the bobwhite, red-headed woodpecker, nighthawk, cardinal, kingbird, and phœbe. Of these birds the bobwhite deserves special mention. As many as 12 of the beetles have been found in the stomach of one bobwhite.

### INSECTS.

The southern corn rootworm has only a few insect enemies, the chief one being a two-winged fly[1] (fig. 7) which attacks it in the beetle stage. This fly places a maggot, or larva, in the abdomen of the beetle, and the maggot feeds on the vital organs of the host and finally kills it. After the death of the beetle the parasite larva, being full grown, enters the ground and forms a tough, leathery case

[1] *Celatoria diabroticae* Shimer.

in which it passes into the next or pupa stage. This case, termed puparium, is dark and covered with needlelike spines. From the puparium there emerges in due time the adult, or fly, which starts the cycle again. This parasite is not very common and thus far has not played a very great rôle in the destruction of the pest.

## PREVENTIVE AND OTHER CONTROL MEASURES.

Although no one method has been discovered which, when applied, will eradicate this pest, yet if the following measures are diligently carried out the ravages of this insect can be reduced markedly.

### BURNING OVER WASTE PLACES.

Large numbers of the beetles are destroyed by burning over waste places, such as the borders and terraces of fields. This should be done in the winter-time and on cool days. Beetles at that time and on such days congregate among dead grasses, seeking protection from cold. The value of this measure is realized when one considers that the killing of one female in winter is as important as the destruction of from 400 to 500 worms in the spring.

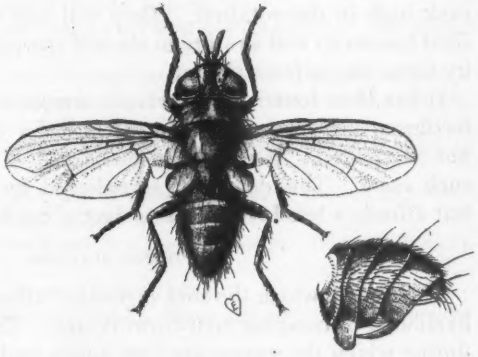

FIG. 7.—A fly enemy of the southern corn rootworm. At the right is shown the piercer by means of which the fly deposits a maggot within the adult or beetle of the rootworm. Fly about eight times natural size.

### CROP ROTATION.

Judicious crop rotation should be carried on wherever possible. It is not well to follow corn with corn. There are several crops that are not injured by these worms, the foremost of them being cotton. Some of the smaller grains are only slightly injured and can, therefore, be used to good advantage in the rotation.

### THICK PLANTING.

It is a common practice among some of the planters in the southeastern States who are acquainted with rootworm injury to plant corn thicker in the lowlands than in the uplands. Double the number of grains are dropped in low ground. This offers twice the chance of securing a stand and is to be recommended especially for fields which consist partly of low ground. The upland in such cases may be

planted in the regular way. In fields of large area this measure loses its value, for if planted thickly some thinning may be necessary and this may mean a loss of labor, time, and money.

### ENRICHING THE SOIL.

It is to be remembered that soil rich in plant food will produce plants that are more hardy, healthy, and capable of resisting insect attack than soil which is not so supplied. Plants injured by the "budworms" sometimes recover and the chances are that a larger percentage will do so in rich than in poor soil. Legumes should rank high in the rotation. They will add to the soil the much desired humus as well as store in the soil the valuable nitrogen extracted by these plants from the air.

It has been found that lowlands supplied abundantly with animal fertilizers are more seriously affected by these worms than those not so treated. It is well to make use of commercial fertilizers in such cases. This does not, as believed by some, repel the insects, but affords a less favorable breeding place for the pest.

### TIMELY PLANTING.

The time at which the corn is planted affects, to a certain extent, its likelihood of escaping rootworm injury. There seems to be a period during which the worms are very active and do much damage. This period varies considerably with the latitude, being somewhat earlier in the extreme South than in more northerly regions. It has been found that corn planted during the latter part of March and after May 10 is less damaged than is that planted during April and the first week in May. There were exceptions, as some corn planted in late March and after May 10 suffered badly, but the largest acreage of injured corn was planted between the dates given.

In each locality, also, these periods naturally will vary somewhat from year to year depending upon the seasonal weather conditions. Every farmer, however, by careful observation extending over a period of years may discover when planting should take place so as to minimize the ravages of this pest, taking into account, of course, other important factors in crop production.

Investigations are now being conducted, in cooperation with the State entomologists of North Carolina and Florida, with a view to the determination of the importance of the time of planting as a factor in "budworm" control.

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Progressive farming methods, as described in this bulletin, will reduce the ravages of this insect. Burn over waste places to destroy dead grass, weeds, and rubbish in which the beetles winter. If possible, avoid planting corn in fields which contained corn the year before. Enrich the soil by planting legumes so that the corn will have a better chance of recovering from rootworm injury. Protect the bobwhite. This bird destroys many beetles of the rootworm. Plant corn late enough to avoid serious injury from rootworms, as recommended on page 10 of this bulletin.

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. Issued May, 1918; revised May, 1922

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## ECONOMIC IMPORTANCE AND COMMON NAMES.

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FIG. 1.—Southern corn rootworm: Larva or worm, side view. About 4½ times natural size.

Although this rootworm sometimes damages the corn crop in the more northerly sections of the Middle West, it is not there consid-

[1] *Diabrotica duodecimpunctata* Fab.; order Coleoptera, family Chrysomelidae.

ered a serious corn pest. A closely allied insect, the western corn rootworm,[2] takes its place as an enemy of corn in these regions.

The southern corn rootworm is more commonly known as the "budworm"; in fact, few farmers know it under the former name. It is sometimes termed "drillworm." These names are more or less descriptive of the injury done to the plant by the worms. The adult, or parent, is known as the 12-spotted cucumber beetle, from the fact that it has 12 black spots on its back and is often a serious enemy to cucumbers and allied plants.

## GEOGRAPHICAL RANGE OF THIS AND RELATED ROOTWORMS.

The southern corn rootworm has a very wide distribution. It is found throughout the greater part of the United States from Maine to Florida, and from the Atlantic coast to the Rocky Mountains. It occurs also in Mexico and Canada. It is not recognized, however, as a serious enemy of Indian corn north of Maryland and the southern parts of Ohio, Indiana, and Illinois, south of Georgia, or west of the Mississippi River, with the exception of parts of southeastern Texas and southern Louisiana. (Fig. 2.)

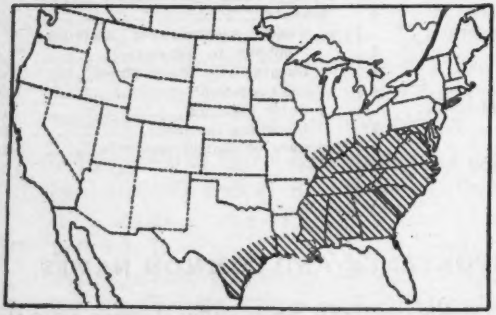

FIG. 2.—Map showing, by shaded area, region where corn is most seriously injured by the southern corn rootworm.

The western corn rootworm[3] occurs from Maine to the Gulf of Mexico and westward to Minnesota, South Dakota, and New Mexico.

In the States bordering the Pacific occurs a closely allied species.[4] This western rootworm is often injurious to various cultivated crops. In southern Texas there is still another species, the belted cucumber beetle,[5] which sometimes does practically as much damage to corn in that region as the southern corn rootworm.

## WHEN SERIOUS INFESTATIONS MAY BE EXPECTED.

Serious infestations of the rootworm may be expected during seasons of abundant rainfall and cool weather, conditions conducive to the development of this insect. Corn in lowlands is more seriously

[2] *Diabrotica longicornis* Say.
[3] *Diabrotica longicornis* Say.
[4] *Diabrotica soror* LeConte.
[5] *Diabrotica balteata* LeConte.

affected than that in uplands, as this insect prefers to breed in moist soil. Thus it is only during years of heavy infestation that corn in uplands is subject to serious damage.

## INJURY TO CORN BY THE ROOTWORM.

The worm or larva stage (fig. 1) of this insect is the one most injurious to corn. As the name "corn rootworm" would indicate, it feeds on the roots of corn, but it does not confine its injuries to the roots; indeed, the greatest damage to young corn is that done by the worms in drilling a small hole into the stem directly above the first circle of roots (see title-page illustration) and feeding on the interior, boring out the crown and killing the bud. Plants affected in this way break off at the injured point when an attempt is made to pull them. In older corn the worms injure the roots almost exclusively.

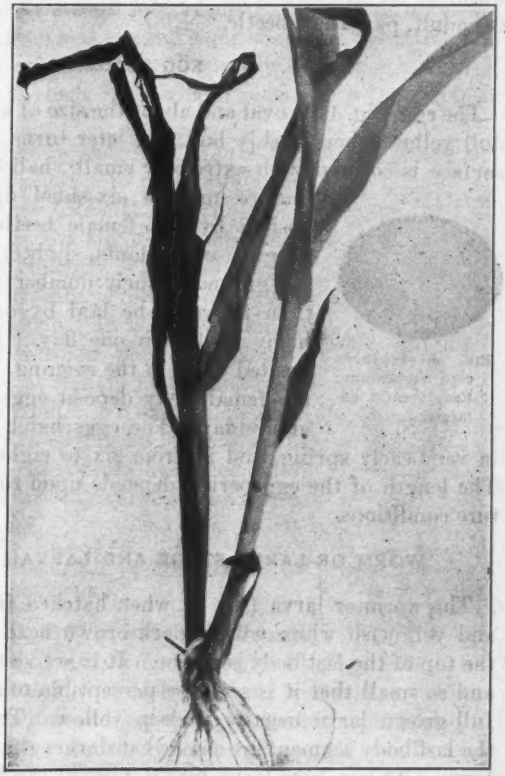

FIG. 3.—Corn plant showing injury by southern corn rootworm to growing point or "bud."

### HOW INJURY TO CORN BY THE ROOTWORM CAN BE RECOGNIZED.

When young corn has been damaged by this insect the fact can be easily detected. The bud leaves of injured plants, having been cut off from the main plant, dry up and die (fig. 3), while the rest of the plant retains its original color for a time. Subsequently the whole plant dies if injured badly. *Badly injured plants occasionally give rise to suckers which may produce ears, but these are usually of a poor quality.* It is on account of the peculiar injury to the bud that the insect is often called the "budworm."

Older plants, when attacked, present a sickly, yellowish, and dwarfed appearance due to the fact that the worms are feeding on the roots. Very often such plants also exhibit a number of suckers which are either sterile or may produce grain of an inferior quality.

## DEVELOPMENT.

The southern corn rootworm has four distinct stages through which it passes in development. The first is the egg, the second the worm or larva, the third the pupa or resting stage, and the fourth the adult, parent, or beetle.

### EGG STAGE.

The egg (fig. 4) is oval and about the size of a large pinhead. It is dull yellow when freshly laid, but later turns a deeper yellow. Its surface is covered with extremely small, shallow pits which in outline resemble a six-sided figure. Eggs are deposited by the female beetle in contact with or near the corn plants, slightly below the surface of the ground. Their number varies greatly. More than 500 may be laid by one individual and as many as 100 in one day. Eggs usually are deposited early in the evening. Sometimes, however, the female may deposit eggs in the daytime, even at midday. The eggs hatch in about three weeks in very early spring, and in from six to eight days in midsummer. The length of the egg period depends upon the prevailing temperature conditions.

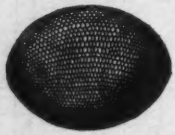

FIG. 4.—Southern corn rootworm: Egg, greatly enlarged.

### WORM OR LARVA STAGE AND LARVAL FOOD PLANTS.

The worm or larva (fig. 1) when hatched from the egg is slender and yellowish white with a dark-brown head and a dark patch on the top of the last body segment. It is active at this stage of growth and so small that it is scarcely perceptible to the unaided eye. The full-grown larva usually is deep yellow. The head and patch on the last body segment are somewhat darker than in the newly hatched larva. The mature larva tapers toward the head end, the last few segments of the body being much wider than the head, which makes them appear as if swollen. The worm stage lasts from three to four weeks. Occasionally, however, the insect may live in this stage from five to six weeks. In the process of development the larva sheds its outer coat twice. This shedding of the skin is known as molting, and is necessaray to enable the larva to increase in size.

Upon examining infested corn one may find the worms in their tunnels or among the roots, though sometimes they are found some

distance away from the injured plants, probably migrating to other corn plants in the same row. Usually only one larva is found at one plant. Sometimes two may be found, but this is the exception.

In addition to corn, the larvæ of this species are known to feed and live on the roots of Johnson grass, Southern chess,[6] wheat, millet, rye, young oats, and alfalfa.

### PUPA OR RESTING STAGE.

After the worm is full-grown it enters the ground to a depth varying from a few inches to a half foot or more, depending upon the texture of the soil. It then makes a cell somewhat oval in outline and smooths it very evenly on the inside. Presently it begins to shorten, and after a few days it sheds its skin and passes into the pupa or resting stage.

What the pupa is like is shown by figure 5. In this stage the insect can not move from place to place and is not destructive. It never leaves its cell. The only part capable of movement is the tip of the abdomen, which is moved about violently when the pupa is disturbed. The pupa is soft, yellowish, and about one-fourth of an inch long. It is a little longer than the width of its broadest part and has two very conspicuous spines at the tip of the abdomen.

The pupa stage lasts from 6 to 8 days in summer, and from 10 to 13 days in spring and fall. At the end of this period the 12-spotted beetle or adult comes forth and works its way through the soil to the surface of the ground.

FIG. 5. — Southern corn rootworm: Pupa or resting stage. About eight times natural size.

### ADULT OR BEETLE STAGE AND FOOD HABITS OF THE BEETLE.

The adult or beetle (fig. 6) is about one-fourth inch long, yellowish-green, with a black head and legs and, as previously stated, with 12 black spots on the back. These spots are irregular in outline and generally somewhat separated.

The beetle is very active during warm weather and can be captured only with difficulty. When feeding, if danger threatens, it falls to the ground and crawls away under rubbish or hides under the foliage of smaller plants. During cool weather it becomes less active, and when the temperature is near freezing it scarcely moves, even when disturbed.

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[6] *Bromus unioloides.*

In this stage the insect often does considerable damage to young corn by cutting off the bud leaves, although such plants usually recover. The adult or beetle is more injurious to certain truck crops than to corn, especially squashes, cucumbers, etc., and on this account is known as the 12-spotted cucumber beetle. Injury to these plants consists of numerous small holes in the leaves, and if plants are small and have only a few leaves much harm is done.

In relation to corn the beetle stage is important as being the egg-laying period of the insect, for the female, after having mated, places her eggs in the soil near the corn plants.

FIG. 6.—Southern corn rootworm: Adult or beetle. About eight times natural size.

## HOW THE INSECT PASSES THE WINTER.

The southern corn rootworm passes the winter in the beetle stage, except possibly in southern Florida and Texas. In northerly regions the beetles go into hibernation late in the fall; that is, they crawl under rubbish and to other places that afford them protection from the cold and remain in an inactive condition during the winter. With the return of warm weather they again become active. In the more southern States, where temperatures are mild, they do not hibernate in the winter, but during cool days and nights hide under rubbish, among dead grasses, or under low-leaved plants, and resume activity when the weather again becomes warm. There are some native plants which remain green throughout the winter in the South, and beetles have been found feeding on them, as well as on alfalfa, rye, oats, and other field crops, during warm days in midwinter.

## NUMBER OF GENERATIONS.

This insect has two generations annually in the region of Columbia, S. C., and it is very likely that it has no more than two anywhere in the United States. Even though the adults of the second generation appear in sufficient time to reproduce the same year, they refrain from so doing until the following spring. The beetles of the second generation do not mate until the approach of fall or cooler weather.

Serious injury to young corn is largely done by the larvæ of the first generation of the year.

## NATURAL ENEMIES.

### NATIVE BIRDS.

A number of our native birds prey upon the adults, or beetles, of the southern corn rootworm. Some of the common ones are the bobwhite, red-headed woodpecker, nighthawk, cardinal, kingbird, and phœbe. Of these birds the bobwhite deserves special mention. As many as 12 of the beetles have been found in in the stomach of one bobwhite.

### INSECTS.

The southern corn rootworm has only a few insect enemies, the chief one being a two-winged fly[1] (fig. 7) which attacks it in the beetle stage. This fly places a maggot, or larva, in the abdomen of the beetle, and the maggot feeds on the vital organs of the host and finally kills it. After the death of the beetle the parasite larva, being full-grown, enters the ground and forms a tough, leathery case in which it passes into the next or pupa stage. This case, termed puparium, is dark and covered with needle-like spines. From the puparium there emerges in due time the adult, or fly, which starts the cycle again. This parasite is not very common and thus far has not played a very great rôle in the destruction of the pest.

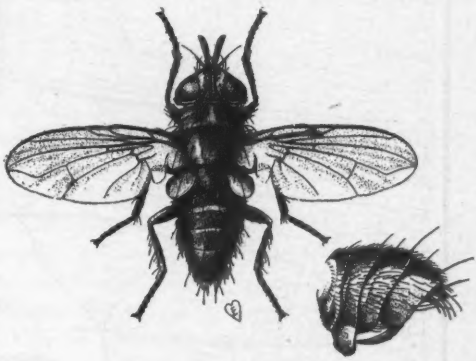

FIG. 7.—A fly enemy of the southern corn rootworm. At the right is shown the piercer by means of which the fly deposits a maggot within the adult or beetle of the rootworm. Fly about eight times natural size.

## PREVENTIVE AND OTHER CONTROL MEASURES.

Various methods, when diligently and thoroughly employed, will aid greatly in preventing injury to corn by the southern corn rootworm. The most important of these methods is timely planting.

[1] *Celatoria diabroticae* Shimer.

### TIMELY PLANTING FOR LOWLANDS SUBJECT TO INFESTATION.[8]

The time at which the corn is planted affects to a large extent its likelihood of escaping rootworm damage. There is a period during which the worms are very active and do much damage. This period varies somewhat with the latitude and to a less extent with the altitude. It is earlier in the extreme South than in the more northerly

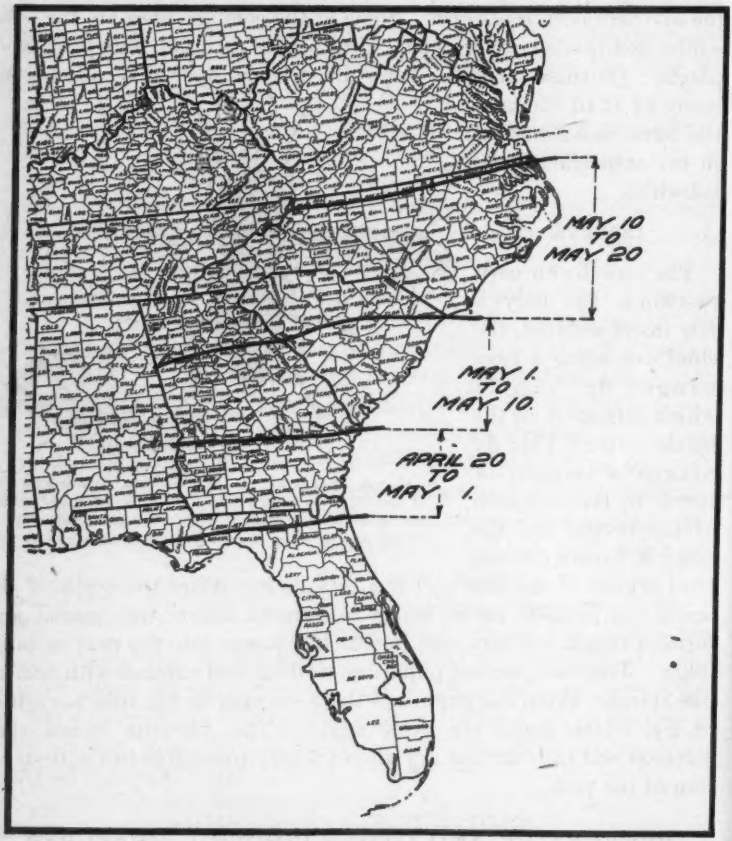


FIG. 8.—Periods during which corn should be planted in order to escape injury from the Southern corn rootworm.

regions and slightly earlier in the lower than in the upper altitudes. The results of the investigations to determine the timely planting periods in infested lowlands of the Southeastern States show that the region may be divided into three belts or zones, each of which has a

[8] In North Carolina the work upon which these recommendations are based was conducted in cooperation with Prof. Z. P. Metcalf, entomologist of the experiment station; in Florida, with Prof. J. R. Watson, State entomologist.

definite planting period. (See fig. 8.) The first or lower zone includes northern Florida and southern Georgia, and has a timely planting period extending from April 20 to May 1. The second or central zone includes central Georgia and the southern half of South Carolina, and here the safe planting period is from May 1 to May 10. The third or upper zone includes northern Georgia, the northern half of South Carolina, and all of North Carolina. The safe planting period for this zone is from May 10 to May 20. Lowlands planted to corn in the three regions during the planting periods recommended will not be seriously infested by rootworms, and many of the plants that are infested under these conditions will recover. Corn planted in Georgia, South Carolina, and North Carolina during April usually suffers severe injury. Plantings made very early in the season occasionally escape damage. However, on account of the danger from frost it is not advisable to plant low grounds as early as this. Furthermore, it is seldom possible to make an early planting. The soil in the lowlands at this time of year is often too wet to permit plowing and a good preparation of the seed bed.

In each locality the safe planting periods naturally will vary somewhat from year to year, depending upon seasonal weather conditions. During exceptionally early seasons the period may be advanced somewhat, while during late seasons it should be delayed. Every farmer, however, by careful observations extending over a period of years, may discover at what date his low ground should be planted so as to minimize the ravages of this pest, taking into account, of course, other important factors in crop production.

### BURNING OVER WASTE PLACES.

Large numbers of beetles are destroyed by burning over waste places, such as the borders and terraces of fields. This should be done in the winter and on cool days. Beetles at that time and on such days congregate in dead grasses, seeking protection from cold. The value of this measure is realized when one considers that the killing of one female in winter is as important as would be the destruction of from 400 to 600 worms in the spring.

### CROP ROTATION.

Judicious crop rotation should be practiced wherever possible. It is not well to follow corn with corn. There are several crops that are not injured by these worms, the foremost of which is cotton. Some of the smaller grains are only slightly damaged and can, therefore, be used to good advantage in the rotation. If a corn crop follows one of the smaller grain crops the same year it will not be damaged by the rootworm, because of lateness of planting.

### THICK PLANTING.

It is a common practice among some of the planters in the southeastern States who are acquainted with rootworm injury to plant corn thicker in the lowlands than in the uplands. Double the number of grains are dropped in low ground. This offers twice the chance of securing a stand and is to be recommended especially for fields which consist partly of low ground. The upland in such cases may be planted in the regular way. In lowlands of large area this measure loses its value, for if corn is planted thickly some thinning may be necessary and this may mean a loss of labor, time, and money; under such conditions timely planting periods should be observed as recommended.

### ENRICHING THE SOIL.

Soil rich in plant food will produce plants that are more hardy, healthy, and capable of resisting insect attack than soil which is not so supplied. Plants injured by the "budworms" sometimes recover, and the chances are that a larger percentage will do so in rich than in poor soil. Legumes should rank high in the rotation. They will add to the soil the much desired humus as well as store in the soil the valuable nitrogen extracted by these plants from the air.

It has been found that lowlands supplied abundantly with animal fertilizers are more seriously affected by these worms than those not so treated. It is well to use commercial fertilizers in such cases. This does not, as believed by some, repel the insects, but affords a less favorable breeding place.

## SUMMARY OF CONTROL MEASURES.

(1) To prevent serious injury to corn by the southern corn rootworm, lowlands in southern Georgia and western Florida should not be planted before April 20 to May 1; in central Georgia and the southern half of South Carolina, not before May 1 to May 10; in northern Georgia, the northern half of South Carolina, and all of North Carolina, not before May 10 to May 20. If possible no corn should be planted in the lowlands in this region during the month of April.

(2) Destroy beetles by burning over waste places in winter.

(3) Practice rotation of crops. Do not follow corn with corn. Follow rotation as recommended by your State Experiment Station or by the United States Department of Agriculture.

(4) Plant low places in fields twice as thick as the uplands. Thin out later if necessary.

(5) Enrich the soil. Raise leguminous crops; these add humus and nitrogen to the soil.

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# The Southern Corn Rootworm and Farm Practices to Control it

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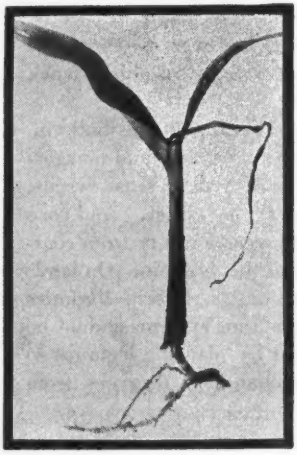

FARMERS' BULLETIN
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Sept. 1940

UNITED STATES DEPARTMENT OF AGRICULTURE

OF ALL CORN PESTS in the South one of the most serious is the southern corn rootworm, the larva, or young, of the 12-spotted cucumber beetle. True to its name, it feeds on the roots, but in young corn it also drills a small hole in the stem just above the first circle of roots, boring out the crown and killing the bud. Attacked plants either die outright or are so badly stunted as to be unproductive. Lowland corn suffers the most, and injury is greatest during cool, damp seasons. The adult, or beetle, is also exceedingly destructive; not, however, to corn, but to cucumber, squash, and a great variety of other truck crops and ornamental plants.

Progressive farming methods, as described in this bulletin, will reduce the ravages of this insect. Terraces and margins of fields should be burned over to destroy dead grass, weeds, and rubbish in which the beetles pass the winter. And corn can be planted late enough to avoid serious injury from rootworms, as recommended on page 7 of this bulletin. On lands subject to infestation in northern areas, hybrid varieties of corn that develop profuse, fibrous root systems should be planted. The soil may be enriched by planting legumes so that the corn will have a better chance of recovery from rootworm injury.

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Washington, D. C.

Issued May 1918
Revised September 1940

# THE SOUTHERN CORN ROOTWORM AND FARM PRACTICES TO CONTROL IT

By PHILIP LUGINBILL, *senior entomologist, Division of Cereal and Forage Insect Investigations, Bureau of Entomology and Plant Quarantine*

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## ECONOMIC IMPORTANCE AND COMMON NAMES

CORN GROWERS in the Southern States suffer damage from the southern corn rootworm (*Diabrotica duodecimpunctata* (F.)) (fig. 1) practically every year. In fact, the rootworm has few competitors as a serious corn pest in the South. During some seasons it is quite a difficult matter to get a stand of corn in the lowlands on account of these "worms." During years of heavy infestation it is necessary to replant corn as many as three times, and even then only a poor stand is obtained. The loss that may be attributed to the ravages of the pest is probably even greater and more far-reaching than is commonly supposed. Very often weather conditions are blamed for the yellowish and sickly appearance of corn and the resulting poor yield of the crop when the true cause is injury done by the southern corn rootworm.

FIGURE 1.—Larva, or grub, of the southern corn rootworm, side view. About 4½ times natural size.

The southern corn rootworm is commonly known as the "budworm"; in fact, few farmers know it under the former name. It is also sometimes termed "drillworm." These names are more or less descriptive of the injury done to the plant by the grubs. The adult, or parent, is known as the 12-spotted cucumber beetle, from the fact that it has 12 black spots on its back and is often a serious enemy to cucumbers and allied plants.

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## GEOGRAPHICAL RANGE OF THIS AND RELATED ROOTWORMS

The southern corn rootworm is found throughout the greater part of the United States, from Maine to Florida and from the Atlantic coast to the Rocky Mountains. It occurs also in Mexico and Canada. It is not recognized, however, as a serious enemy of corn north of Maryland and the southern parts of Ohio, Indiana, and Illinois, south of Georgia, or west of the Mississippi River, with the exception of parts of southeastern Missouri, eastern Arkansas, southeastern Texas, and Louisiana (fig. 2).

A closely allied western insect, the corn rootworm (*Diabrotica longicornis* (Say)) takes its place to some extent in the Middle West and also is found from Maine to the Gulf of Mexico and westward to Minnesota, South Dakota, and New Mexico.

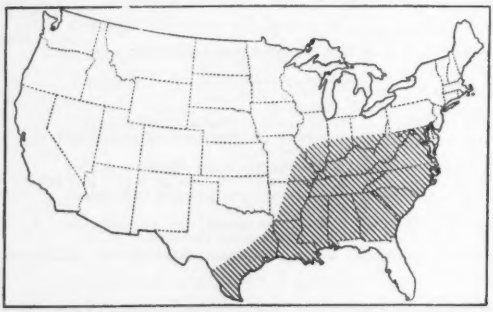

FIGURE 2.—The shaded areas on this outline map of the United States show the region where corn is most seriously injured by the southern corn rootworm.

In the States bordering the Pacific Ocean occurs another closely allied species known as the western spotted cucumber beetle (*Diabrotica soror* LeConte), which in its grub stage is a rootworm attacking various cultivated crops. In southern Texas there is still another species, the banded cucumber beetle (*Diabrotica balteata* LeConte), which sometimes does practically as much damage to corn in that region as does the southern corn rootworm.

## WHEN SERIOUS INFESTATIONS MAY BE EXPECTED

Serious infestations of the rootworm may be expected during seasons of abundant rainfall and cool weather, conditions conducive to the development of this insect. Corn in lowlands is more seriously affected than that in uplands, as this insect prefers to breed in moist soil. Thus it is only during years of heavy infestation that corn in uplands is subject to serious damage.

## INJURY TO CORN BY THE ROOTWORM

The "worm" or larval stage (fig. 1) of this insect is the one most injurious to corn. As the name "corn rootworm" would indicate, it feeds on the roots of corn, but it does not confine its injuries to the roots; indeed, the greatest damage to young corn is that done by the worm in drilling a small hole into the stem directly above the first circle of roots and feeding on the interior, boring out the crown and killing the bud (fig. 3). Plants affected in this way break off at the injured point when an attempt is made to pull them.

## HOW INJURY TO CORN BY THE ROOTWORM CAN BE RECOGNIZED

When young corn has been damaged by this insect the fact can be easily detected. The bud leaves of injured plants, having been cut off from the main plant, dry up and die (see cover page illustration), while the rest of the plant retains its original color for a time. Subsequently the whole plant dies if injured badly. Badly injured plants occasionally give rise to suckers which may produce ears, but these are usually of a poor quality. It is on account of the peculiar injury to the bud that the insect is often called the "budworm," but this name is frequently applied to several other kinds of insect.

When the worms feed on the roots of older plants they cause them to fall over .or lodge (fig. 4), or to appear sickly or stunted and send up a number of suckers which are either sterile or will produce grain of an inferior quality.

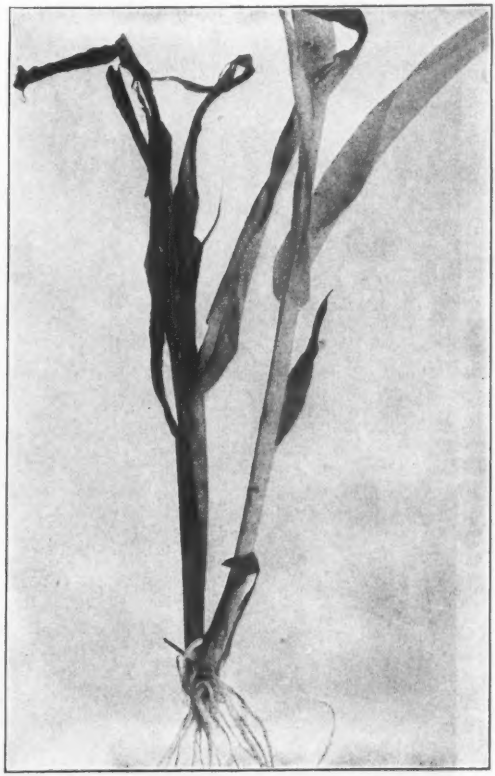

FIGURE 3.—Corn plant showing injury by southern corn rootworm to growing point or "bud."

## DEVELOPMENT OF THE INSECT

The southern corn rootworm has four distinct stages through which it passes in its development. The first is the egg, the second the grub or larva, the third the pupa, or resting stage, and the fourth the adult, parent, or beetle.

### EGG STAGE

The egg (fig. 5) is oval and about the size of a large pinhead. It is dull yellow when freshly laid but later turns a deeper yellow. Its surface is covered with extremely small, shallow pits which in outline resemble six-sided figures. Eggs are deposited by the female beetle slightly below the surface of the ground among various herbaceous plants. Their number varies greatly. More than 500 may

be laid by one individual and as many as 100 in 1 day. Eggs usually are deposited early in the evening. Sometimes, however, the female may deposit eggs in the daytime, even at midday. The eggs hatch in about 3 weeks very early in the spring and in from 6 to 8 days in midsummer. The length of the egg period depends on the prevailing temperature.

## GRUB, OR LARVAL STAGE, AND LARVAL FOOD PLANTS

The grub, or larva, when first hatched is slender and yellowish white with a dark-brown head and a dark patch on the top of the last

FIGURE 4.—Corn plants fallen or lodged because of injury to the roots done by the southern corn rootworm.

body segment. It is active at this stage of growth but so small that it is scarcely perceptible to the unaided eye. The full-grown larva usually is deep yellow. The head and patch on the last body segment are somewhat darker than in the newly hatched larva. The mature larva (fig. 1) tapers toward the head end, the last few segments of the body being much wider than the head, which makes them appear

as if swollen. The grub stage lasts from 3 to 4 weeks. Occasionally, however, the insect may live in this stage from 5 to 6 weeks. As the larva increases in size, it molts, or sheds its outgrown skin, twice.

When infested corn is examined the grubs may be found in their tunnels or among the roots, though sometimes they are some distance away from the injured plants, probably migrating to other corn plants in the same row. Usually only one larva is found at one plant, but sometimes, though rarely, there may be two.

In addition to corn, the larvae of this species are known to feed and live on the roots of Johnson grass, southern chess or rescue grass (*Bromus catharticus* Vahl.), wheat, millet, rye, young oats, and alfalfa.

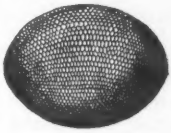

FIGURE 5.—Egg of the southern corn rootworm, magnified about 12 times.

## PUPA, OR RESTING STAGE

After the larva is full-grown it enters the ground to a depth ranging from a few inches to a half foot or more, depending on the texture of the soil. It then makes a cell somewhat oval in outline and smooths it very evenly on the inside. Presently the larva begins to shorten, and after a few days it sheds its skin and passes into the pupal or resting stage (fig. 6).

In this stage the insect cannot move from place to place and is not destructive. The only part capable of movement is the tip of the abdomen, which is moved about violently when the pupa is disturbed. The pupa is soft, yellowish, about one-fourth of an inch long, and has two very conspicuous spines at the tip of the abdomen.

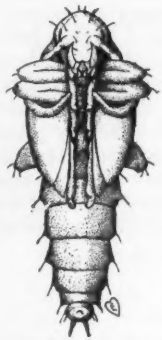

FIGURE 6.—Pupa, or resting stage, of the southern corn rootworm, magnified about eight times.

The pupal stage lasts from 6 to 8 days in summer and from 10 to 13 days in spring and fall. At the end of this period the 12-spotted beetle, or adult, comes forth and works its way through the soil to the surface of the ground.

## ADULT, OR BEETLE STAGE, AND FOOD HABITS OF THE BEETLE

The adult or beetle (fig. 7), the egg-laying stage of the insect, is about one-fourth inch long, yellowish-green, with a black head and legs and, as previously stated, with 12 black spots on the back. These spots are irregular in outline and generally somewhat separated.

The beetle is very active during warm weather and can be captured only with difficulty. If danger threatens it when feeding, it falls to the ground and crawls away under rubbish or hides under the foliage of small plants. During cool weather it becomes less active, and when the temperature is near freezing it scarcely moves, even when disturbed.

In this stage the insect often does considerable damage to young corn by cutting off the bud leaves, although such plants usually recover. The adult, or beetle, is more injurious to certain truck crops

than to corn, especially to squashes, cucumbers, etc., and on this account is known as the 12-spotted cucumber beetle. It injures these plants by making numerous small holes in the leaves, and if the plants are small and have only a few leaves much harm is done.

In relation to corn the beetle stage is important as being the egg-laying period of the insect, for the female, after having mated, places her eggs in the soil near the corn plants.

## HOW THE INSECT PASSES THE WINTER

The southern corn rootworm passes the winter in the beetle stage, except possibly in southern Florida and Texas. In more northerly regions the beetles go into hibernation late in the fall; that is, they crawl under rubbish and to other places that afford them protection from the cold and remain in an inactive condition during the winter. With the return of warm weather they again become active. In the upper margin of this range of infestation the insect apparently dies at the end of each season, and the area is reinfested each year by migrant beetles coming from points farther south. In the more southern States, where temperatures are mild, the beetles do not hibernate in winter, but during cool days and nights hide under rubbish, among dead grasses, or under low-leaved plants and resume activity when the weather again becomes warm. In the South, there are some native plants which remain green throughout the winter, and beetles have been found feeding on them, as well as on alfalfa, rye, oats, and other crops, during warm days in midwinter.

FIGURE 7.—Southern corn rootworm: Adult or 12-spotted cucumber beetle. About eight times natural size.

## NUMBER OF GENERATIONS

This insect has two complete generations annually in the vicinity of Columbia, S. C. Even though the adults of the second generation appear in sufficient time to reproduce the same year they refrain from doing so until the following spring. The beetles of the second generation do not mate until the approach of fall or cooler weather.

Serious injury to young corn in the South is largely done by the larvae of the first generation of the year.

## NATURAL ENEMIES

### NATIVE BIRDS

A number of our native birds prey upon the adults, or beetles, of the southern corn rootworm. Some of the common ones are the bobwhite, red-headed woodpecker, nighthawk, cardinal, kingbird, and

phoebe. Of these birds the bobwhite deserves special mention. As many as 12 of the beetles have been found in the stomach of one bobwhite.

### INSECTS

The southern corn rootworm has only a few insect enemies, the chief one being a two-winged fly, *Celatoria diabroticae* (Shimer) (fig. 8), which attacks it in the beetle stage. This fly places a maggot, or larva, in the abdomen of the beetle, and the maggot feeds on the vital organs of the host and finally kills it. After the death of the beetle the parasite larva, being then full-grown, enters the ground and forms a tough, leathery case in which it passes into the next or pupal stage. This case, called a puparium, is dark and covered with needle-like spines. From the puparium there emerges in due time the adult, or fly, which starts the cycle over again. This parasite is not very common and thus far has not played a very great role in the destruction of the pest.

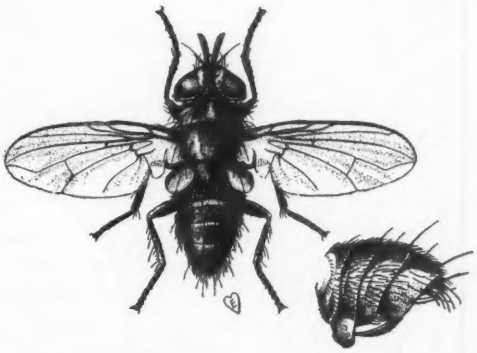

FIGURE 8.—*Celatoria diabroticae*, a fly enemy of the southern corn rootworm. At the right is shown the piercer by means of which the fly deposits a maggot within the adult or beetle of the rootworm. Fly about eight times natural size.

## PREVENTIVE AND OTHER CONTROL MEASURES

Various methods, when diligently and thoroughly employed, will aid greatly in preventing injury to corn by the southern corn rootworm. The most important of these methods is timely planting.

### TIMELY PLANTING FOR LOWLANDS SUBJECT TO INFESTATION[1]

The time at which the corn is planted affects to a large extent its likelihood of escaping rootworm damage. There is a period during which the worms are very active and do much damage. This period varies somewhat with the latitude and to a less extent with the altitude. It is earlier in the extreme South than in the more northerly regions and slightly earlier in the lower than in the upper altitudes. The results of investigations to determine the best planting periods in infested lowlands of the Southeastern States show that the region may be divided into three belts, or zones, each of which has a definite planting period (fig. 9). The first or lower zone includes northern Florida and southern Georgia, and has a safe planting period extending from April 20 to May 1. The second or central zone includes central Georgia and the southern half of South Carolina, and here the safe planting period is from May 1 to May 10. The third or upper

[1] In North Carolina the work upon which these recommendations are based was conducted in cooperation with Z. P. Metcalf, entomologist of the North Carolina Agricultural Experiment Station; in Florida, with J. R. Watson, State entomologist.

zone includes northern Georgia, the northern half of South Carolina, and all of North Carolina. The safe planting period for this zone is from May 10 to May 20. Corn planted in the lowlands in the three regions during the planting periods recommended will not be seriously infested by rootworms, and many of the plants that are infested under these conditions will recover. Corn planted in Georgia, South Caro-

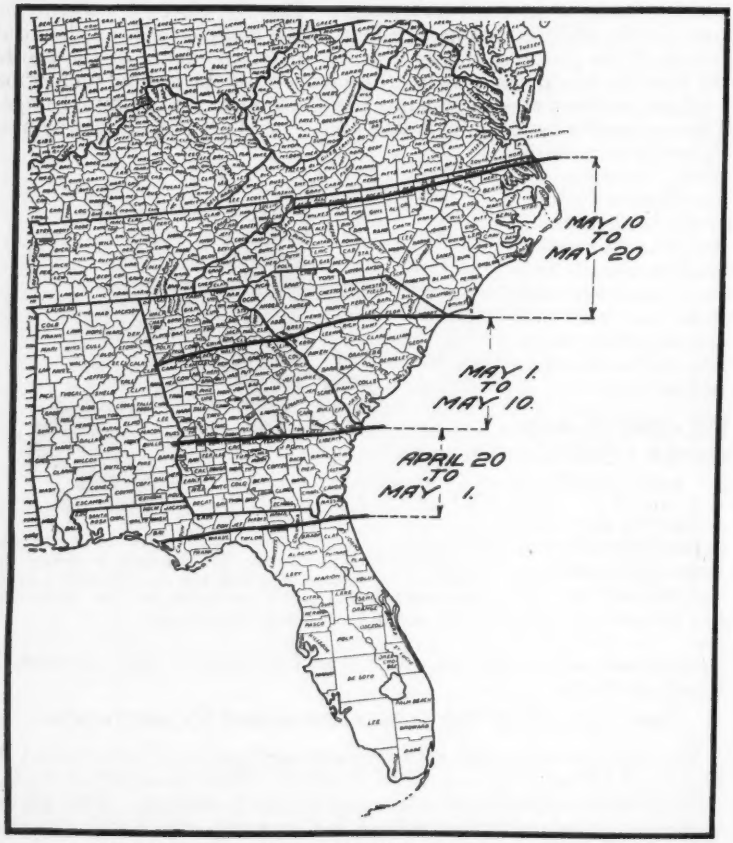


FIGURE 9.—Periods during which corn should be planted in order to escape injury from the southern corn rootworm.

lina, and North Carolina during April usually suffers severe injury. Plantings made very early in the season occasionally escape damage, but on account of the danger from frost it is not advisable to plant low grounds as early as this. Furthermore, it is seldom possible to make an early planting. The soil in the lowlands at this time of year is often too wet to permit plowing and a good preparation of the seed bed.

In each locality the safe planting periods naturally will vary somewhat from year to year, depending on seasonal weather conditions.

During exceptionally early seasons the period may be advanced somewhat, whereas during late seasons it should be delayed. Every farmer, however, by careful observations extending over a period of years, may discover at what date his low ground should be planted so as to minimize the ravages of this pest, taking into account, of course, other important factors in crop production.

Where soil conditions permit, injury to young corn may sometimes be avoided by plowing the land very early in the season, or at least a month before the corn is to be planted. Any rootworms surviving this treatment will reach maturity before the corn is planted, and the resulting beetles will leave the field in search of suitable growing vegetation in which to lay their eggs. The plowed land should be kept barren until planting time in order to prevent the further deposition of eggs by the beetles.

### BURNING OVER WASTE PLACES

Large numbers of beetles may be destroyed by burning over waste places, such as the borders and terraces of fields, in the winter and on cool days. Beetles at that time and on such days congregate in dead grasses, seeking protection from cold. The value of this measure is realized when one considers that the killing of one female in winter is as important as would be the destruction of from 400 to 600 worms in the spring.

### PLANTING HYBRID VARIETIES OF CORN THAT PRODUCE ABUNDANT FIBROUS ROOT SYSTEMS

In the more northerly range of the southern corn rootworm, where injury to corn is mainly the destruction of the roots and subsequent lodging of the stalks, hybrid varieties of corn which develop profuse fibrous root systems suffer less damage than those having a limited supply of coarse roots. The corn grower in this section, before planting lands subject to infestation, should consult the local county agricultural agent or the nearest experiment station regarding the best hybrid varieties of corn to plant in his locality.

### THICK PLANTING

It is a common practice among some of the planters in the Southeastern States who are acquainted with rootworm injury to plant corn thicker in the lowlands than in the uplands. Double the number of grains are dropped in low ground. This offers twice the chance of securing a stand and is to be recommended especially for fields that consist partly of low ground. The upland in such cases may be planted in the regular way. In lowlands of large area this measure loses its value, for if corn is planted thickly some thinning may be necessary and this may mean a loss of labor, time, and money. Under such conditions the best planting periods should be observed as recommended.

### ENRICHING THE SOIL

Soil rich in plant food will produce plants that are more hardy, healthy, and capable of resisting insect attack than soil that is not so supplied. Plants injured by the "budworms" sometimes recover,

and the chances are that a larger percentage will do so in rich than in poor soil. Judicious crop rotation should be practiced wherever possible. Legumes should rank high in the rotation. They will add to the soil the much desired humus as well as store in the soil the valuable nitrogen extracted by these plants from the air.

It has been found that lowlands supplied abundantly with animal fertilizers are more seriously affected by these worms than those not so treated. It is well to use commercial fertilizers in such cases. These do not, as is believed by some, repel the insects. but afford them a less favorable breeding place.

## SUMMARY OF CONTROL MEASURES

(1) To prevent serious injury to corn from the southern corn rootworm, lowlands in southern Georgia and western Florida should be planted between April 20 and May 1; in central Georgia and the southern half of South Carolina, between May 1 and May 10; in northern Georgia, the northern half of South Carolina, and all of North Carolina, between May 10 and May 20. If it is possible to avoid it, plant no corn in the lowlands in this region during April. If possible, plow lowlands early in the season, at least 1 month before planting to corn.

(2) Destroy beetles by burning over field borders and terraces in winter.

(3) Plant low places in fields twice as thickly as the uplands. Thin out later if necessary.

(4) Enrich the soil. Raise leguminous crops; these add humus and nitrogen to the soil.

(5) Plant profusely rooting, hybrid corn varieties in areas where root damage is severe.

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